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DOI:

[10.1016/j.jbtep.2016.01.001](https://doi.org/10.1016/j.jbtep.2016.01.001)

Document Version

Peer reviewed version

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Citation for published version (APA):

Duncko, R., & Veale, D. (2016). Changes in disgust and heart rate during exposure for Obsessive Compulsive Disorder: A case series. *Journal of Behavior Therapy and Experimental Psychiatry*, 51, 92-99.
<https://doi.org/10.1016/j.jbtep.2016.01.001>

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Changes in Disgust and Heart Rate during Exposure for Obsessive Compulsive Disorder: a
Case Series

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RUNNING HEAD: Disgust and Heart Rate in OCD

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Keywords: obsessive compulsive disorder; disgust; anxiety; heart rate

Highlights

- State disgust and heart rate was measured in participants with OCD during exposure
- 54.5% participants had increased disgust and absent heart rate acceleration
- Disgust correlated with RMSSD indicating on increased vagal tone during experiments

Abstract

Background and Objectives: The emotion of disgust has been suggested as a factor contributing to a poor response to Cognitive Behavior Therapy (CBT) in the treatment of Obsessive Compulsive Disorder (OCD). However, only limited information is available about the phenomenology of disgust in clinical OCD and the physiological mechanisms involved. This case series was designed to explore the phenomenology of OCD and the physiological activity associated with the emotion of disgust.

Methods: State disgust and heart rate was measured in eleven participants attending treatment for OCD during exposure relevant to their individual formulation.

Results: All participants with contamination and most patients with blood and injury related fears experienced a prominent increase in state disgust during exposure. These participants also had absent heart rate acceleration during exposure. Disgust response correlated with heart rate response ($r=-0.63$, $p<0.01$) and Root Mean Square of Successive Differences (RMSSD) ($r=0.52$, $p<0.01$).

Limitations: The design using ecologically valid stimuli and the limited number of participants did not allow between subject comparisons or more detailed analysis of relationship between trait and state disgust and between disgust and severity of OCD.

Conclusions: Our findings show that a large proportion of our case series with OCD experience prominent disgust with signs of increased vagal tonus during their exposure. Such experiences differ from the concept of adrenergic activation used for psychoeducation in CBT and appraisals of harm and this may result in poorer therapeutic outcome.

Keywords: obsessive compulsive disorder; disgust; anxiety; heart rate; exposure

Cognitive Behaviour Therapy (CBT) including the Exposure and Response Prevention (ERP) represents the first line treatment recommended for Obsessive Compulsive Disorder (OCD) (NICE, 2005) but this treatment approach is still accompanied by considerable dropout rates (20%) and treatment resistance (20%) (Foa, 2010). One of the factors contributing to limited effectiveness of CBT may be the co-occurrence of emotions such as disgust (Woody & Teachman, 2000).

Disgust can be characterized by a desire to distance oneself from the object of disgust, a fear of oral incorporation of the object of disgust and a feeling of “revulsion” (Davey, 1994). Several components of trait disgust have been identified, including: (i) Core disgust, which relates to the threat of oral incorporation of food or body waste products (“guardian of the mouth”) (ii) Animal reminder disgust, which relates to reminders of our own mortality and inherent animalistic nature (“guardian of the body”). This relates to our attitudes and practices regarding sex (e.g. incest), death and injury to the body or violations of the outer envelope, (iii) Contamination disgust, which involves contact with individuals who are unknown, tainted by disease, misfortune or immorality (Olatunji et al., 2007b; Rozin & Fallon, 1987). These 3 components can be measured with the Disgust Scale-Revised (Haidt, McCauley, & Rozin, 1994, Olatunji et al., 2007b) and other self-report measures have been developed to assess other specific components of disgust. These measures have been used extensively in studies investigating the role of disgust in various mental health conditions and it has been suggested that disgust can play a significant role in the development and maintenance of anxiety disorders such as specific phobias, blood and injury phobia or OCD (Cisler, Olatunji, & Lohr, 2009).

Significant amount of research has been focused on links between disgust and symptoms of OCD. Studies of nonclinical samples by several research groups indicate a strong association between trait disgust and OCD-related fears (Cisler, Reardon, Williams, &

Lohr, 2007; Mancini, Gragnani, & D'Olimpio, 2001; Moretz & McKay, 2008; Olatunji, Haidt, McKay, & David, 2008; Schienle, Stark, Walter, & Vaitl, 2003) and this relationship was confirmed in a prospective study (Olatunji, 2010). Results from studies with clinical populations are less consistent with a significant relationship between disgust and contamination OCD reported by two research groups (Melli, Bulli, Carraresi, & Stopani, 2014; Melli, Chiorri, Carraresi, Stopani, & Bulli, 2015a, Olatunji, Tart, Ciesielski, McGrath, & Smits, 2011) while only small size correlations were found by others (Woody & Tolin, 2002). A more recent research identified disgust avoidance as a factor involved in contamination OCD with possible influence on therapy outcome (Melli, Chiorri, Carraresi, Stopani, & Bulli, 2015b). To explore the role in maintenance of OCD, several studies investigated changes in disgust in response to possible treatment procedures showing that disgust is more resistant to extinction (Mason & Richardson, 2010; Olatunji, Forsyth, & Cherian, 2007a) and habituates more slowly than anxiety (Adams Jr, Willems, & Bridges, 2011; McKay, 2006; Olatunji, Wolitzky-Taylor, Willems, Lohr, & Armstrong, 2009). These findings demonstrate the importance of improving our understanding of disgust in order to be able to address this emotion during the treatment of OCD (Mason & Richardson, 2012). One of the approaches suggested for identifying mechanisms involved in the link between disgust and OCD is the focus on physiological correlates of disgust.

Since the early studies, disgust was reported to be associated with specific patterns of psychophysiological activity. This includes a group of measures related to the known facial expression of disgust (Ekman, 1973) such as the increased activity of corrugator (Lang, Greenwald, Bradley, & Hamm, 1993) and levator labii facial muscles (van Overveld, de Jong, & Peters, 2009; Vrana, 1993). Another measure commonly associated with disgust is increased electrodermal activity likely reflecting a general activation during a negative emotion (de Jong, van Overveld, & Peters, 2011; Lang et al., 1993; Rohrman, Hopp,

Schienle, & Hodapp, 2009; van Overveld et al., 2009) but the main differentiating measures appear to be those reflecting sympathovagal balance related to cardiovascular function. State disgust is associated with increased vagal activity or sympathetic withdrawal as demonstrated by reduced heart rate (Lang et al., 1993; Levenson, 2003; Meissner, Muth, & Herbert, 2011; Rohrmann et al., 2009), increased T wave amplitude (van Overveld et al., 2009) and increased high frequency band power of the heart rate variability (de Jong et al., 2011; Meissner et al., 2011). The importance of identifying such changes in sympathovagal balance in disorders such as OCD relates to the fact that the focus on sympathetic activation during treatment of OCD may not be relevant for patients experiencing symptoms of vagal activation and may contribute to higher dropout rates and less favourable treatment outcomes (Mason & Richardson, 2012). In contrast to the extensive literature on the psychophysiology of disgust in the nonclinical population, only inconsistent data are reported in individuals with clinical OCD. A recent clinical research did not find significant association between disgust in OCD and psychophysiological response but this study did not include measures of cardiovascular sympathovagal balance (Whitton, Henry, & Grisham, 2015). Studies examining measures, such as heart rate in patients with OCD during negative affect, report heart rate acceleration (Rabavilas & Boulougouris, 1974; Stein, Arya, Pietrini, Rapoport, & Swedo, 2006), deceleration (Hoehn-Saric, McLeod, & Hipsley, 1995; Simon, Kaufmann, Kniesche, Kischkel, & Kathmann, 2013) or no changes (Zahn, Leonard, Swedo, & Rapoport, 1996) but only a few of these studies attempted to differentiate between emotions such as anxiety and disgust. Another possible explanation for such contradictory results is the individual variability of responses to disgust-eliciting stimuli in the context of the differing phenomenology of symptoms between participants.

Most of the preclinical or clinical studies investigating the relationship between disgust and symptoms of OCD and the physiological mechanisms involved have used

procedures with specific standardized disgust elicitors presented uniformly to participants in the study. However, a person's individual responses to disgust or anxiety triggers can vary widely depending on their personal history and experiences (Ellsworth & Scherer, 2003). The use of individually identified stimuli has been employed in early as well as more recent studies investigating psychophysiological features of OCD (Rabavilas & Boulougouris, 1974, Simon et al., 2013) and the need for using ecologically valid methods was also pointed out in other areas of OCD research (Radomsky & Rachman, 1999). Such use of idiosyncratic stimuli can interfere with traditional research designs relying on group comparisons and single case series designs have been suggested as a possible tool to capitalize on such individual variability (Kazdin, 2011). This approach has frequently been used in studies evaluating new therapeutic approaches but also in exploratory studies on psychophysiology of OCD (Rabavilas & Boulougouris, 1974) and other idiosyncratic phenomena (Caramazza, 1986).

The present study utilized a multiple single case design to explore the phenomenology associated with disgust in individuals with OCD and to test the hypothesis that disgust is associated with contamination OCD symptoms. Our second aim was to determine whether an individually identified elicitor of disgust is associated with heart rate deceleration similar to those observed in a nonclinical population. Lastly, we attempted to explore the link between state disgust experienced during exposure and the severity of OCD, depressive symptoms and trait disgust.

Methods

Design

The study was designed as a naturalistic descriptive study using the AB design with multiple baselines. To allow an attempt at generalization of results, the design was extended

using the clinical replication series approach (Hayes, Barlow, & Nelson-Gray, 1999) and data obtained from multiple single cases were correlated to explore possible links between experienced disgust and psychological and physiological measures as has been reported in larger case series (Arts, Kols, Onderwater, & Peul, 2012).

Participants

The study included 11 consecutive patients attending for treatment of OCD at the Anxiety Disorders Residential Unit at the Bethlem Royal Hospital, London who agreed to participate. There were 9 male and 2 female patients. The inclusion criteria were ongoing CBT, age over 18 years and primary diagnosis of OCD. The diagnosis according to DSM-IV (American Psychiatric Association, 2000) was established during a clinical interview including a Structured Clinical Interview for DSM-IV (Spitzer, Gibbon, & Williams, 1998) and confirmed by the consensus of the clinical team. The exclusion criteria were English language level insufficient for participating in CBT and completing required questionnaires, or lack of capacity to provide informed consent. The main obsessions and compulsions of participants were as follows:

Case I was a 47 year old woman with intrusive thoughts and images of hurting others, triggered in social contexts. She also experienced contamination fears mostly related to her home environment. To neutralize the thoughts of harming others she engaged in compulsive washing and cleaning at home and avoidance of social situations.

Case A was a 28 year old man with intrusive thoughts and images of losing control and hurting others and fears of becoming a dangerous psychopath followed by increasing avoidance of social situations such as traveling by tube or train, avoidance of children and performance of mental compulsions with self-reassurance.

Case J was a 32 year old woman with intrusive thoughts of contracting stomach illness either by eating contaminated food or from contact with people carrying stomach

bugs. These were accompanied by excessive ritualized hand washing and avoidance of potentially contaminated foods to the point of severe restriction of food intake and weight loss. She had a comorbid specific phobia of vomiting and social anxiety, which had deteriorated during recent years while she remained socially isolated and not able to continue with her vocational interests.

Case H was a 29 year old man with a fear of contracting illness from contaminated food and infecting others, as well as intrusive thoughts with anti-religious content including sex and blasphemy resulting in him avoiding contact with any possibly contaminated items and washing excessively and compulsively. Developmental aspects included a strong religious family background and a history of food poisoning with subsequent anxiety related gastrointestinal problems.

Case D was a 23 year old man with a fear of contracting an unspecified illness from possible skin contact with biological fluids such as blood, urine or semen. Routes of the feared contamination included food (primarily) and contact with non-sterilized clinical equipment, clothes or cutlery. He also had a strong sense of moral disgust and mental contamination in the context of his older sister having a sexual relationship with his friend whilst he was at the same school.

Case F was a 34 year old man with intrusive thoughts of hurting strangers and images of mutilated dead bodies. He feared that he would lose control and kill someone or abuse a child if there is no one nearby to protect them. His symptoms had deteriorated against the background of the recent birth of his first child. To neutralize his fears he was compulsively seeking reassurance from his wife and was avoiding any situations of being on his own with strangers or his child.

Case G was a 19 year old man with a fear of saying something or doing something inappropriate in common social situations which would reflect on him as a bad and weird

person. He was also experiencing recurrent intrusive thoughts of not being able to make the right decision. This resulted in frequent occasions of being stuck and not able to proceed with basic daily activities as well as increasing social withdrawal.

Case E was a 28 year old man with intrusive thoughts of having left something important behind (a wallet, car keys) with subsequent excessive checking in situations such as using an ATM or even leaving from a bench in a park.

Case B was a 30 year old man with intrusive thoughts of damaging equipment such as smartphone or laptop by leaving fingerprints or stains on it on the background of long term perfectionism and Asperger syndrome.

Case C was a 33 year old man with a fear of causing harm to himself or others by not being careful enough. He was particularly preoccupied with harm to his eyes possibly caused by sun light or infection with a strong sense of self-criticism. He had excessive avoidance of situations perceived as harmful to his eyes such as direct sunshine or windy weather.

Case K was a 29 year old man with a fear of harming others by stabbing or crashing into them while he was driving with a strong emphasis on moral code but no prominent images of mutilated or dead bodies. He was engaging in mental neutralizing by debating and goading himself and was increasingly avoidant of social situations.

Measures

The following measures were taken at baseline and during each exposure.

State anxiety. The state anxiety was measured on a 0-10 Likert rating scale where 0 represented “no anxiety at all” and 10 was “the worst possible anxiety”.

State disgust. The state disgust was measured by using 10-point Likert rating scales where 0 represented “no disgust at all” and 10 was “the worst possible disgust”.

Heart rate. The heart rate was recorded at baseline and during the exposure with a Polar RS800CX heart rate monitor using a H2 chest sensor. Polar monitors have been tested against standard clinical ECG equipment and found to be suitable for heart rate variability analysis (Vanderlei, Silva, Pastre, Azevedo, & Godoy, 2008). Heart rate was calculated as the average heart rate during a 1 minute interval at baseline and during each exposure. The one minute length of interval was identified as a realistic maximal length of in vivo exposures for some of the participants. As the 1 minute interval is not sufficient to reliably evaluate the Low Frequency band of heart rate variability (Berntson et al., 1997) the frequency analysis of heart rate variability was not performed. Instead the Root Mean Square of the Successive Differences (RMSSD) was calculated for the same 1 minute intervals to evaluate changes in vagal tonus during exposures.

The following measures were taken at baseline only.

Disgust Scale – Revised (DS-R; Haidt et al., 1994; Olatunji et al., 2007b). The DS-R was used to assess the trait disgust and the components of Core disgust, Animal Reminder disgust and Contamination disgust. It is a 25 item self-report scale with all items rated on 5 point scale. The Cronbach's alpha for each of the 3 subcomponents were reported to be above 0.70.

Yale-Brown Obsessive Compulsive Scale (Y-BOCS; Goodman et al., 1989). The Y-BOCS is a 10-item clinician-rated scale used to measure the severity of obsessive-compulsive symptoms. Each item was scored from 0 (no symptoms) to 4 (extreme symptoms), and items were summed to give a total score with a range of 0 to 40. The Cronbach's alpha was reported to be 0.89.

Patient Health Questionnaire (PHQ-9; Kroenke, Spitzer, & Williams, 2001). The PHQ-9 is a 9 item self-report scale used to assess the severity of depressive symptoms. The range is 0 to 27. The Cronbach's alpha was reported as 0.86-0.89.

Procedure

After recruitment and signing the consent form, each participant completed the baseline measures of DS-R and PHQ-9. Y-BOCS for each participant was completed during the assessment interview. Then they identified the exposure task to be utilized in the study. In our service, exposure is presented as a behavioural experiment to test out an alternative understanding of the problem in a way that helps residents to tolerate the anxiety. This largely overlaps with modern exposure procedures (Craske, Treanor, Conway, Zbozinek, & Vervliet, 2014). Exposure tasks included situations ranging from laboratory-like (watching video clips on the computer) to natural real life experiments (standing on a train platform in busy station, see Table 1 for examples). On the day of the study, participants placed the heart rate monitor on their chest at the beginning of each session. The baseline 1 minute heart rate recording was obtained. If the in vivo exposure took place outside the clinic, the baseline recording was also taken outside the clinic in the absence of any physical activity. The baseline ratings of state anxiety and disgust were taken at the same time as the heart rate recording. Individual interventions were all planned to test out participants' current beliefs and were set up to last approximately 1 minute. Heart rate was recorded and peak ratings of state anxiety and disgust were taken. Most subjects participated on 2-3 study days using different scenarios for their behavioral experiments.

Data analysis

To evaluate the phenomenology associated with disgust, participants were ranked by their disgust response. To achieve this, changes in anxiety and disgust were calculated for individual exposures and plotted. The scatterplot was assessed visually to evaluate the predominant pattern for each participant. Participants were then ranked by their average

individual change in state disgust during the intervention. After identifying the participants with the highest disgust response, the phenomenology of their symptoms was explored. To test the hypothesis of heart rate deceleration occurring during disgust, physiological response during the intervention was visually evaluated by calculating individual changes in heart rate and plotting them against the rank of disgust response. The role of vagal activity in heart rate changes was assessed by calculating the change in RMSSD for each exposure and a correlation was calculated between changes in RMSSD and disgust. To evaluate the link between levels of disgust and severity of OCD and depressive symptoms, Spearman correlation coefficients between the rank of disgust response and Y-BOCS and PHQ-9 scores were calculated. To evaluate the association between Trait Disgust established by DS-R and changes in state disgust during intervention we computed the correlation coefficients between the average total score in DS-R as well as average partial scores for Core, Animal-Reminder and Contamination disgust and the rank of disgust response.

Results

Eleven patients with OCD (average Y-BOCS score 31.36) participated in a total of 54 sessions of exposure (3-9 sessions per patient) while recording their state anxiety, state disgust and heart rate. Individual exposure tasks were identified on each participant's hierarchy and were relevant to their formulation (Table 1). Visual analysis of changes in state anxiety and disgust during these behavioral experiments revealed that 6 of 11 participants (54.5%) experienced increased disgust during all of their sessions of exposure at a magnitude comparable to the increase of anxiety during these situations (Figure 1).

Evaluation of heart rate changes during exposure showed that participants with a prominent state disgust response showed heart rate deceleration or absence of heart rate acceleration (Figure 2). Due to the non-normal distribution of values, Spearman correlation

was used to evaluate the association of heart rate and RMSSD changes with the state disgust response. Correlation analysis of all exposures recorded returned a significant negative correlation between state disgust response and heart rate response ($r=-0.64$, $p<0.01$). There was also significant correlation between state disgust response and RMSSD ($r=0.52$, $p<0.01$) and heart rate response and RMSSD ($r=-0.86$, $p<0.01$).

The review of individual formulations revealed that all participants with strong contamination fears had a prominent state disgust response with heart rate deceleration or lack of increase (cases D, H and J). The other 3 participants with high state disgust response (cases I, A and F) were experiencing intrusive thoughts and images of harming others with strong moral disgust and imagined blood and injury. In contrast to this, participants with heart rate acceleration and less prominent state disgust response during exposure had a variety of obsessive thoughts including harm avoidance with less pronounced focus on blood and injury (case C), obsessions about order, cleanliness and staying in control (cases B and E) and intrusive thoughts about decision making with a component of fear of social scrutiny (case G). One participant with heart rate acceleration and no prominent increase in state disgust (case K) had obsessive thoughts about harming others including fears of blood and injury (by stabbing or crushing with a car) but no prominent images of dead or mutilated bodies.

Overall scores in DS-R appeared to be skewed towards the participants with higher state disgust responses (Table 2) but the correlation analysis returned only non-significant correlation coefficient of 0.34. Similarly, only non-significant correlations with state disgust changes were found for partial scores for Core ($r=0.40$), Animal Reminder ($r=0.34$) and Contamination disgust ($r=0.16$). There was no noticeable tendency for higher Y-BOCS scores in patients with high state disgust ($r= -0.12$).

Nine of eleven participants were taking prescribed antidepressant medication with 7 patients at the maximum licensed dose (Table 3). The only 2 patients with no prescribed

SSRI or tricyclic medication had a prominent state disgust response (cases A and J). Several patients experienced depressive symptoms during their therapy but only three of them fulfilled the criteria for depressive episode at the start of their therapy. All 3 patients with depressive episode (Table 3) belonged to those with prominent state disgust response (cases I, J and F). Four more patients (H, G, E and K) had high PHQ-9 scores but these were attributed to symptoms of OCD such as avoidance and social withdrawal and the correlation between PHQ-9 and state disgust response was not statistically significant.

Discussion

The aims of our study were to explore the phenomenology of OCD of participants experiencing significant disgust during exposure and the associated physiological activity. Our results indicate that all of our participants with contamination and most participants with blood and injury related fears were experiencing a prominent increase in state disgust during exposure. More importantly, our study is the first to show that in addition to the subjective perception of disgust during individually tailored exposure tasks these participants experienced a decrease in heart rate associated with signs of increased vagal activity.

Our finding of a prominent disgust response in a high proportion of patients with severe OCD extends the previous findings from nonclinical and clinical studies (Cisler et al., 2007; Mancini et al., 2001; Melli et al., 2014; Moretz & McKay, 2008; Olatunji, 2010; Olatunji et al., 2011; Olatunji, et al., 2007b; Schienle et al., 2003). The analysis of phenomenology showed that a prominent disgust response was associated with contamination OCD which is in accordance with some of the previous studies (McKay, 2006). We also found a prominent disgust response in participants with intrusive thoughts of harming others who had strong visual imagery. This may be related to the blood and injury aspect of their fears and is in accordance with well documented presence of disgust in blood and injury

phobia (Tolin, Lohr, Sawchuk, & Lee, 1997). Our finding of a prominent disgust response in participants with contamination OCD is consistent with a recent report identifying two factors in fears of contamination, harm avoidance and disgust avoidance where the latter was the stronger predictor of contamination OCD (Melli et al., 2015b). Unfortunately, our data do not allow differentiation of harm avoidance and disgust avoidance and further studies are needed to explore the link between disgust avoidance, actual experiences of prominent disgust response and associated autonomic activity.

The heart rate deceleration or lack of heart rate increase observed in patients with a predominant disgust response during exposure was associated with increased RMSSD and indicates an increased vagal tonus during these situations. This finding is in accordance with a number of studies measuring heart rate during disgust in non-clinical populations but does not support findings from clinical population documenting heart rate acceleration in response to disgust eliciting images (Stein et al., 2006). Our explanation is that the disgust response to standardized stimuli such as pictures is likely to have high individual variability due to different interpretations depending on individual backgrounds and experiences. In contrast to this, the design used in our study allowed us to use individual triggers relevant to each participant and was more likely to elicit pronounced physiological and emotional changes. More importantly, our data are more likely to reflect the actual experiences during therapy and real life exposures of these patients. While some of the literature indicates that increased vagal activity can be specific to physical as opposed to moral disgust (Ottaviani, Mancini, Petrocchi, Medea, & Couyoumdjian, 2013), in our study the absence of heart rate increase was also noted for participants with moral disgust related to harm avoidance (participants A, F, I) which could be attributed to the strong blood and injury component observed in their symptoms. Such physiological response appears to be in accordance with the biphasic response with heart rate deceleration reported for patients with blood and injury phobia (Öst,

Sterner, & Lindahl, 1984) and is also in support of preclinical findings of heart rate deceleration associated with injury or animal reminder disgust (Harrison, Gray, Gianaros, & Critchley, 2010; Shenhav & Mendes, 2014).

Our finding shows that despite the high ratings of anxiety during exposure a proportion of patients did not experience the increase in heart rate as a common sign of sympathetic activation. CBT for OCD includes psychoeducation focusing on physiological processes associated with sympathetic activation during the fight or flight response and explaining physical perceptions of palpitations, dry mouth, tight chest and throat as normal physiological processes. This can facilitate the understanding that the distress associated with anxiety triggers is temporary and will subside in absence of safety seeking or compulsive behaviours. In contrast to this, the disgust reaction reported by us and others appears to be associated with increased saliva production (van Overveld et al., 2009), reduced heart rate (Lang et al., 1993; Levenson, 2003; Meissner et al., 2011; Rohrmann & Hopp, 2008; Rohrmann et al., 2009) or nausea combined with increased perspiration (Meissner et al., 2011). Our data indicate that more than 50% of participants in our case series with severe OCD can experience symptoms of vagal activation during exposure and therefore their personal experience can significantly differ from the one described by the classic anxiety response. It can be argued that such discrepancy may result in reduced socialization with the model and subsequently poorer therapeutic outcome.

Our data show that the prominent disgust response in OCD does not appear to be associated with significantly higher scores on DS-R but the design of our study does not allow rejecting the hypothesis of such association. Similarly, our data are not indicative of any pronounced association between state disgust response and Y-BOCS score but further research is needed to test the hypothesis that an increased state disgust response is associated with higher severity of OCD.

We attempted to explore the possibility of prescribed medications and comorbidity contributing to pronounced perception of disgust. The pattern of medication use in our participants did not indicate a strong association with disgust experienced during exposure. In addition to anxiety disorders, disgust has been reported to be associated with depressive symptoms (Powell, Simpson, & Overton, 2013). Our results indicate that individuals with severe OCD who have a prominent disgust response may represent an increased risk for comorbid depression but the current study did not have the design or power to test this hypothesis.

The main limitation of the present study is that due to the case series design with limited number of participants the study does not have sufficient power to evaluate the relationship between trait and state disgust and between disgust and severity of OCD. Paradoxically, this is also one of the strengths of this study as the case series design was selected with the clear purpose of reflecting what patients with severe clinical OCD experience during their therapy. We believe that the method of individually identified triggers for each patient represents a significant contribution in the field of researching the spectrum of emotions in OCD and that it will help clarifying some of the inconsistencies in the literature. We suggest that this approach can be implemented to further investigate mechanisms involved in development and maintenance of conditions such as OCD and lead to modifications of currently used treatment protocols. An assessment should first include whether disgust is experienced with anxiety. The rationale might include a more nuanced psycho-education about the experience of disgust during exposure and its evolutionary context. This might include understanding the expectations during exposure or developing strategies for increasing tolerance of disgust, as well as alternative approaches such as counterconditioning or unconditioned stimulus revaluation (Ludvik, Boschen, & Neumann, 2015). Further limitations of our study include the small number of participants not allowing

a meaningful exploration of links between disgust response and DS-R scores or symptoms of depression. Our study also did not include measures assessing recently reported factors of trait guilt and disgust avoidance (Melli et al., 2015a, Melli et al., 2015b) and further research is needed to investigate possible links between these factors and psychophysiological correlates of disgust in OCD patients. This can be attempted by using larger clinical samples to achieve sufficient statistical power for correlations with specific dimensions of obsessive compulsive symptoms analyses or by identifying clinical features differentiating groups of patients which would allow using group comparison design.

To our knowledge, this is the first study presenting data on changes in disgust and cardiovascular indicators of vagal tone in response to individually identified triggers in patients with severe OCD. Our findings show that a large proportion of these patients experience significant amounts of disgust associated with signs of increased vagal tone during their exposure. Further research is needed to investigate the significance of these findings for clinical outcomes and to test possible modifications to current treatment protocols.

Acknowledgements

This study presents independent research part-funded by the National Institute for Health Research (NIHR) Biomedical Research Centre at South London and Maudsley NHS Foundation Trust and King's College London. The views expressed are those of the author(s) and not necessarily those of the NHS, the NIHR or the Department of Health. None of the authors report any conflict of interest.

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Figure 1

Changes in State Disgust and State Anxiety experienced during exposure. Dashed line marks zero disgust change to identify participants with disgust response during all exposures (empty markers) in contrast to participants with only occasional or absent disgust response (filled markers).

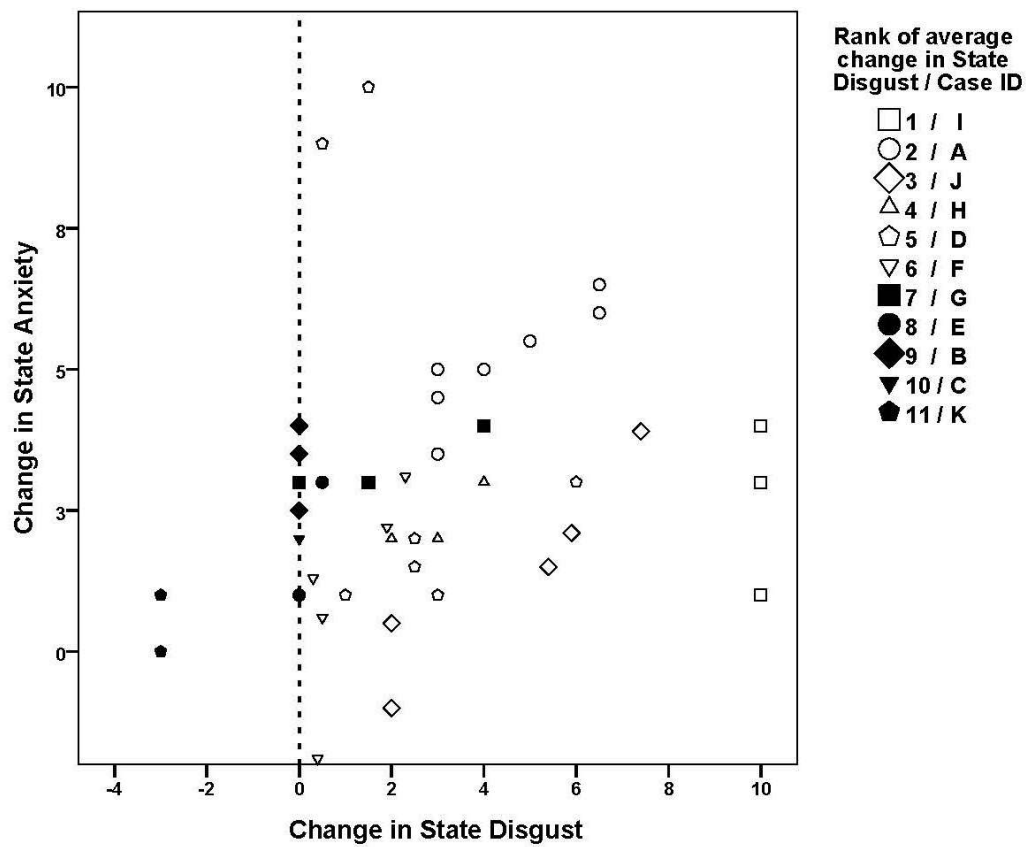


Figure 2

Changes in heart rate in participants ranked by their average disgust response from the highest (1) to the lowest (11). Dashed line marks zero change in heart rate. Participants with the rank 1-6 identified as those with prominent disgust response during exposure had absent increase in heart rate.

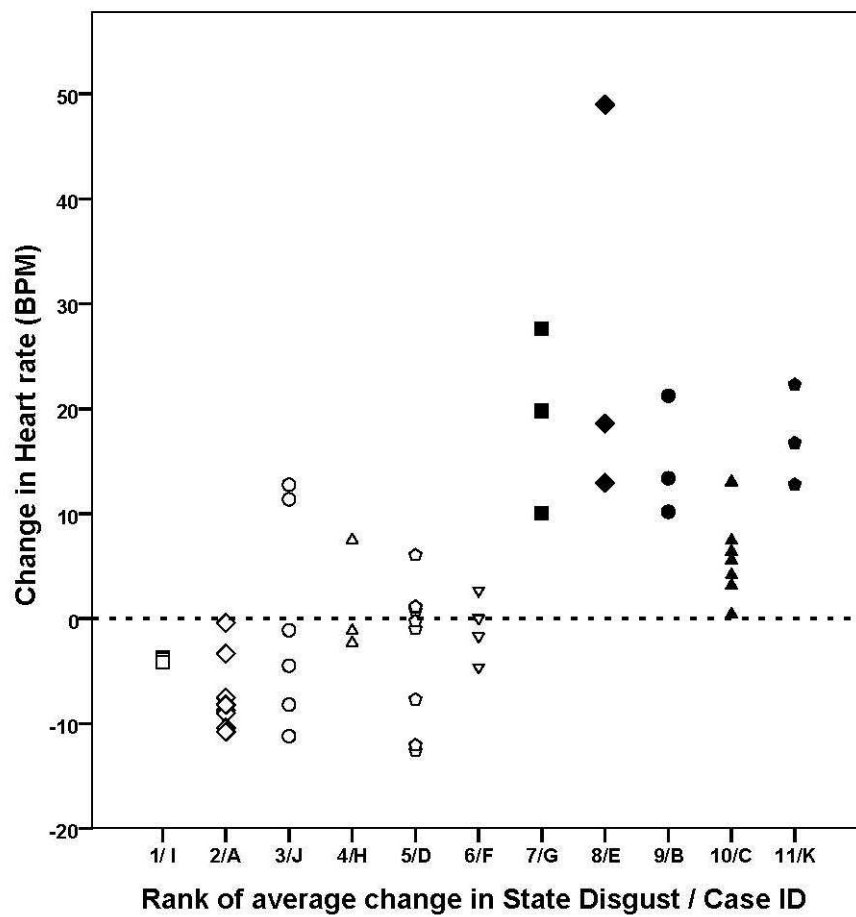


Table 1

Examples of exposure/ behavioral experiments and tested beliefs in participants ordered by the rank of their average change in disgust during these experiments.

Disgust rank	Case	Exposure/ Behavioral experiments	Tested belief
1	I	Sitting in a busy café, watching people pass triggering intrusive thoughts and images of hurting them physically or abusing them verbally. Writing down these thoughts for her therapist to read.	<p>Theory A: I am a terrible and bad person for having such thoughts and everyone would despise me for these thoughts if they knew about them.</p> <p>Theory B: I am a person who is very worried and disgusted by such thoughts, which are against my values.</p>
2	A	Standing on the edge of a train station platform behind the therapist when train approaching.	<p>Theory A: I may impulsively push the therapist off the platform and kill him and be a horrible, dangerous person.</p> <p>Theory B: I am person who worries a great deal about harming others, which is against my values.</p>
3	J	Watching videos of people vomiting.	Theory A: When I watch the video, it will make me vomit and it

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will go on forever and be awful.

Theory B: I am very fearful of vomiting because of past experiences of vomiting from my childhood.

- | | | | |
|---|---|--|--|
| 4 | H | Swallowing a piece of cheese possibly touched by someone else. | <p>Theory A: The cheese is likely to be contaminated and eating it will cause stomach problems.</p> <p>Theory B: I am very fearful of possible stomach problems because of my past experiences.</p> |
| 5 | D | Physical examination including auscultation with a stethoscope and ECG recording. Touch a sharps box in the clinical room and not wash hands afterwards. | <p>Theory A: The stethoscope, ECG equipment or sharps box have not been sterilized and can transmit unspecified germs and cause unspecified illness.</p> <p>Theory B: I am a person who is very fearful of diseases possibly transmitted by biological fluids or non-sterilized equipment.</p> |
| 6 | F | Sitting alone on a bench in a remote area of the hospital campus. | <p>Theory A: I am likely to kill a random person if there is no one else around which means that I am a bad person and cannot be trusted.</p> |

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			Theory B: I worry a lot about causing possible harm to others and that is against my values.
7	G	Ordering a burger from a street vendor.	<p>Theory A: I won't be able to make the right decision and I am likely to blurt out something inappropriate.</p> <p>Theory B: I worry a lot about making wrong decisions or doing something inappropriate impulsively.</p>
8	E	Putting all items from his pockets on a table in a café, then putting them quickly back in and leaving without checking.	<p>Theory A: I am likely to leave something important behind, which means that I am not in control.</p> <p>Theory B: I am a person who is fearful of appearing erratic and not in control.</p>
9	B	Using his smartphone in public and not checking for possible damage afterwards.	<p>Theory A: Even normal use of equipment is likely to cause damage to it, which means that I have failed to look after my equipment.</p> <p>Theory B: I am a person who worries a lot about not having things in perfect order.</p>
10	C	Standing on a platform of a busy station while	Theory A: I will accidentally bump into someone and we will

passengers from an arriving train are rushing past him. Exposing his face to direct sunlight and preventing covering his forehead with his hand.

both fall off the platform onto train tracks. I will cause harm to my skin and eyes if I am not careful.

Theory B: I am a person who worries about harm to me by accident or not being careful.

11 K Allowing the therapist to lean over his hand while he chops a banana using his non-dominant hand.

Theory A: My hand could slip up and stab the therapist.

Theory B: I tend to worry a lot about possibly harming others, which is against my values.

Table 2

Calculated scores on the Yale-Brown Obsessive Compulsive Scale (YBOCS) and Disgust Scale-Revised (DS-R) in participants ordered by the rank of their average change in disgust. Partial scores in DS-R are calculated as the mean value for items specific for the particular area of symptoms.

Disgust rank	Case	YBOCS	DS-R			
			Total score	Core Disgust	Animal reminder Disgust	Contamination Disgust
1	I	33	2.96	2.92	3.63	2
2	A	24	1.64	1.67	2.13	0.8
3	J	29	2.32	2.67	2.13	1.8
4	H	32	2.04	2.25	2.63	0.6
5	D	27	3.08	2.42	3.5	4
6	F	39	2.4	2	3.63	1.4
7	G	36	2.6	2.67	2.63	2.4
8	E	40	1.8	2	2.13	0.8
9	B	25	2.04	2.25	2.13	1.4
10	C	30	1.76	1.58	2.38	1.2
11	K	30	1.96	2.25	2.13	1

Table 3

Scores on the Patient Health Questionnaire (PHQ-9), prescribed medication and psychiatric comorbidity in participants ordered by the rank of their average change in disgust.

Disgust rank	Case	PHQ-9	Medication	Comorbidity
1	I	33	escitalopram 30mg, pregabalin 225mg, quetiapine 50mg	Depression
2	A	24	None	None
3	J	29	None	Specific phobia of vomiting, depression
4	H	32	citalopram 60mg, risperidone 2mg	None
5	D	27	fluoxetine 60mg	None
6	F	39	sertraline 200mg	Depression
7	G	36	sertraline 150mg	None
8	E	40	clomipramine 200mg	None
9	B	25	duloxetine 60mg, lamotrigine 25mg	Asperger's syndrome
10	C	30	sertraline 200mg	None
11	K	30	sertraline 75mg	None